

# October 2006



## CERDEC Headquarters



## Table of Contents

## NIGHT VISION AND ELECTRONIC SENSORS DIRECTORATE

Thermal Imaging	1
Image Intensification	1
Advanced Optics & Displays	2
Laser/Laser Radar	2
Image and Signal Processing (e.g., Automatic/Aided Target Recognition)	2
Countermine/Improvised Explosive Devices (IEDs)	2
Sensor Modeling & Simulation	2
Systems Level Integration	3
Sensor Networks	3
Deception	3

**INTELLIGENCE AND INFORMATION WARFARE DIRECTORATE**

Intelligence, Surveillance, and Reconnaissance ISR Sensors	3
SIGINT	3
COMINT	4
ELINT	4
MASINT	4
RADINT	4
Multi-INT	4
Intelligence, Surveillance and Reconnaissance ISR Processing	4
Electronic Warfare / Force Protection	4
Information Operations	5
Combat Identification	5
Modeling and Simulation	5

**COMMAND AND CONTROL DIRECTORATE**

Battle Command	6
Visualization of Battlefield Information	6
Service Based Software Technologies for Plan Execution & Monitoring	6
Mobile Computing Middleware	6
Rapid Capture of Commanders' Knowledge	6
Contextual Information Management	6
Knowledge Management	6
Web-Based Technologies for Planning	6
Common Graphics Unit Interface (GUI) to Virtual Services	6
Visual Displays	6
Immersive 3D	7
Interactive Speech	7
Machine Language Translation/Natural Language Processing	7
Position Navigation	7
Positioning, Navigation & Timing	7
Algorithms for organic unmanned sensor systems/platforms	7
Future Force Power	7
Fuel Cells & Hybrid Systems	8
Power Management	8
Electromechanical Devices & Systems	8
Ultracapacitors	8
Rechargeable Batteries	8
Primary (Disposable Batteries	8
Battery Chargers	8
Heat Actuated Cooling	8
Renewable Energy Sources	8
Prototype Development & Platform Integration Technologies	8

**SPACE & TERRESTRIAL COMMUNICATION DIRECTORATE**

Information Assurance	9
Antennas	9
Mobile Networking	9
Systems Engineering	9
Mobile Laser Communications	10

**T**he RDECOM Communications-Electronics Research Development and Engineering Center (CERDEC) conducts Technical Interchange Meetings (TIMs) to discuss relevant industry Independent Research and Development (IR&D) programs. The key to a successful IR&D program is effective two-way communications between the Department of Defense (DoD) and industry. The companies present their IR&D projects relevant to DoD technological needs and the Government provides constructive feedback to them. This document lists CERDEC's technologies of interest for the current year and will be used as a baseline for our IR&D TIMs. The TIMs are a win-win process; improving future business opportunities for industry by focusing technology on CERDEC needs, and helping our engineers identify emerging technologies important to future CERDEC systems.

## Night Vision & Electronic Sensors Directorate (NVESD)

**Mission:** Conduct research and development to provide the Warfighter with advanced sensor technology that will acquire and target enemy forces; detect and neutralize mines, minefields and unexploded ordnances; deny enemy surveillance and acquisition through electro-optics, camouflage, concealment, and deception techniques; provide for night driving and pilotage; and protect troops and fixed installations from enemy intrusion.

**NVESD has the primary responsibility for Department of Defense (DOD) Electro-Optics. Business areas include:**

**Ground Combat Systems** - Develop combat vehicle, Soldier and unmanned ground vehicle (UGV) sensor systems to acquire and target enemy forces and for night fighting and driving.

**Air Systems** - Develop rotocraft and unmanned air vehicle (UAV) sensor systems to acquire and target enemy forces and for pilotage.

**Countermine** - Develop systems to detect and neutralize mines, improvised explosive devices (IEDs), minefields and unexploded ordnance for military and humanitarian demining operations.

**Science & Technology** - Conduct research and foster maturation of electro-optics/infrared (EO/IR) and countermine sensor components and of aided target recognition (ATR) signal processing schemes.

**Modeling & Simulation** - Develop models and simulations and perform sensor component and systems performances analyses.

**Special Products & Prototyping** - Develop unique systems to protect forward troops, fixed installations and rear echelons from enemy intrusion.

### Night Vision and Electronic Sensors Directorate Technology Area Needs:

#### 1. Thermal Imaging

Thermal imagers or infrared (IR) viewers (also known as forward looking infrared (FLIR)) gather the infrared radiation in the midwave/longwave (MW/LW) spectral regions and form an electronic image for the Soldier. Thermal imagers are light-level independent since they gather, primarily, emitted scene radiation and have significant penetration capabilities through obscurants such as fogs, hazes, and conventional battlefield smokes. There are two varieties of thermal imaging systems: cooled and uncooled.

There are two varieties of thermal imaging systems: cooled and uncooled.

- Novel new techniques in molecular beam epitaxy (MBE) growth and device fabrication for multi/hyperspectral IR focal plane arrays (FPAs), esp., with Mercury-Cadmium-Telluride (HgCdTe)
- Alternative low cost substrates for MW/LW HgCdTe detectors
- Innovative read-out integrated circuits (ROICs) and on-chip processing architectures
- IR pixel miniaturization and large format cooled and uncooled IR FPAs
- Short time constant (~ 1ms) uncooled IR detectors
- Multiband uncooled IR FPAs
- Type II superlattice IR FPAs with higher operating temperatures
- Improved bake stability in vanadium oxide (VOx) and amorphous silicon (a-Si) uncooled detector materials
- Temperature stabilization techniques for advanced high performance IR FPAs
- Low cost manufacturing and processing for cooled/uncooled IR sensors
- Sun spot resistant VOx
- New uncooled materials and devices
- New thermo electric (TE) cooler materials

#### 2. Image Intensification

Image intensifiers capture ambient light and amplify it thousands of times by electronic means to display the battlefield to a Soldier via a phosphor display such as night vision goggles. This ambient light comes from the stars, moon or sky glow from distant man-made sources, such as cities. A Soldier can

conduct his combat missions without any active illumination sources using only image intensifiers.

- All solid state short wave infrared (SWIR) for low light level imaging
- Low cost, high performance image intensified TVs for pilotage applications
- Small size, large format SWIR cameras with and without thermo electric cooling
- Electronically coupled image intensifier (EI2) tube and complementary metal-oxide semiconductor (CMOS) read-out integrated circuit (ROIC)
- Monolithic microchannel plate (MCP)/CMOS ROIC for EI2
- Low noise ROIC (<10 electrons) charge couple device/CMOS architectures
- Extended near infrared response for EI2



- Alternative visible/near infrared low light level digital imagers
- Low halo/gated electron bombarded active pixel sensor (EBAPS)
- Dark current suppression and low 1/f noise processes

### 3. Advanced Optics and Displays

Advanced optics and displays improve the Army's capability to operate in all battlefield conditions. These technologies provide the Army with new, or enhanced, capabilities to see and target farther on the battlefield, operate in obscured conditions, and maintain a higher degree of situational awareness (SA). These technologies support Future Combat Systems (FCS) and the Future Force.

- Low cost, light weight optical materials and components (reflective & refractive)
- Low cost optics for distributed aperture, disposable imagers and Soldier equipment
- Sub wavelength structures (SWS)
- Low reflectivity optics for uncooled infrared
- Low power miniature panel displays
- Diffractive optical elements (DOE)
- Variable transmissive optical components
- Variable f/# infrared optics
- Spatial color super-eXtended graphics array (SXGA) micro display
- Application-specific integrated circuit (ASIC) display electronics design for spatial color SXGA micro display
- Improved efficiency of red-green-blue backlight for transmissive micro displays
- Improved helmet mounted displays for aviation

### 4. Laser/Laser Radar

Small compact laser devices and systems are needed to perform a myriad of sensor related functions, such as range finding, pointing, designation, atmospheric sensing obstacle avoidance and 3D laser imaging. Eye safe laser systems for the Soldier system must be light weight and low power and very compact.

- Laser range finders
- Low cost, high efficiency, compact eye safe lasers
- Short pulse (< 1 ns), moderate energy (>100mJ) eye safe lasers
- Lightweight laser designators (less than 4 pounds)
- 2D detector arrays and read out integrated circuit (ROIC) for high resolution 3D laser radar (LADAR)
- Coherent LADAR detector arrays with coherent eye safe transmitters

- Lightweight multi-mode laser (pointer/rangefinder/designator).
- Wire detection, wind sensing and obstacle avoidance techniques

### 5. Image and Signal Processing (e.g., Automatic/Aided Target Recognition (ATR) and Fusion)

Digital signal processing techniques are used to extract and reduce sensor information for use by the weapons platform or Soldier. Image enhancement, bandwidth compression, automatic/aided target recognition and data/image fusion are the primary examples of the capabilities that the signal processing can provide.

- Techniques/measurements for polarization imaging in the longwave/midwave/shortwave (LWIR/MWIR/SWIR) spectral regions
- Automated image enhancement and optimization
- Visible/near infrared MWIR/LWIR sensor fusion methods and metrics
- Multifunctional signal processing
- Real time multi frame image processing for MWIR, SWIR and LWIR
- Super resolution processing techniques for uncooled and cooled infrared focal plane arrays
- Urban moving target indicator (MTI) processing of pop up or fleeting targets while on the move
- Phenomenology studies and ATR algorithm development for single color sensors, multi-band sensors, hyperspectral sensor
- Simple, efficient moving target indication and change detection algorithms
- Improvements to ATR algorithms using battlefield network, global positioning system and digital map information

### 6. Countermine/Improvised Explosive Devices (IEDs)

The focus is on the maturation and demonstration of sensor and neutralization technologies required to detect and mitigate the effects of mines, minefields, improvised explosive devices (IEDs) and obstacles to enable assured mobility for the high operational tempo (OPTEMPO) of the Future Force, and where feasible, exploit opportunities to enhance Current Force capabilities.

- Down looking and forward looking mine detection sensors and processing algorithms for anti-tank (AT) mines on/off roads
- Small AT/anti-personnel (AP) mine detection sensors for dismounted applications
- Wide area airborne minefield detection sensors and processing
- Mine/minefield detection payload for Class 3 unmanned aerial vehicle (UAV)



- Confirmation sensors for countermine (e.g., chemical, nuclear quadrupole resonance, pulse-neutron, acoustic)
- Precision mine neutralization technologies from standoff
- Polarization techniques for ground based wire and detonation cord detection
- Techniques to detect and neutralize improvised explosive devices from standoff distances
- High altitude airborne electro-optic/infrared (EO/IR) (<2" GSD) sensing technologies for roadside IEDs/mines
- High altitude day/night persistent surveillance technologies for vehicle borne improvised explosive devices (VBIEDs)
- Automated change detection analysis systems
- Vehicle-mounted systems for detecting and/or neutralizing roadside IEDs/mines in real time.
- Forward-looking magnetic/electromagnetic/radar sensing for IED detection
- Chemical sensing of explosives
- High power radio frequency techniques for detecting/neutralizing remote controlled IEDs
- Visible/IR sensing of mines/IEDs



### 7. Sensor Modeling and Simulation

The sensor modeling and simulation area focuses on the technology maturation in critical areas such as; modeling target acquisition tasks of search, detection, recognition, and identification for currently inadequate representations in military operations in urban terrain, specific targets, and moving targets. Multispectral sensor simulations will support end-to-end predictive modeling and evaluation of

new technologies in virtual combat simulations.

- Multi-spectral infrared (IR) (3rd Generation IR) and IR/image intensification image fusion
- Advanced image processing techniques, known as "super-resolution", that can provide extended identification range staring sensors
- Detection and discrimination of "non-traditional" targets to support Urban Operations and the Global War on Terrorism (GWOT)
- Discrimination of threats based on spectral emissions (muzzle flash, exhaust)
- Detection and discrimination metrics for moving observer versus moving targets
- Aided target recognition model for use in wargame simulations

## 8. Systems Level Integration

Integrating the sensor onto the platform involves interfacing the sensor to the platform. These interfaces can be mechanical, electrical, data, etc.

- System on-a-chip processing
- Lightweight non-magnetic head tracking
- Ultra-miniature inertial measurement unit (IMU)/ global positioning system (GPS)
- Ultra-miniature inertially stabilized pan and tilt systems
- Develop system components to improve the target location accuracy and repeatability for manportable applications in urban and non-urban environments, e.g., azimuth determination (digital magnetic compass, gyroscopic, and GPS based navigation)
- Reduced power processors
- High accuracy digital compasses for improved target location error
- Low power high resolution color day video cameras and flat panel color displays
- Compass/vertical angle measurement (C/VAM) after digital compasses – high accuracy digital compasses C/VAM for improved target location error
- Laser protection
- Passive millimeter wave imagers

## 9. Sensor Networks

Distributed sensor networks are becoming more prevalent on the battlefield. Whether unattended sensor networks or sensors netted together across weapons platforms, the effective and efficient fusing of data, features, images, geospatial information, etc. from all sensors will be critical to effective battle management.

- Disposable micro-sensors and integrated communication links
- Lightweight, compact, low power computing for

on-board processing of high definition imagery in near real-time

- High density processors for sensors
- Self organization sensor networks
- Low cost and power unattended networked sensors and communications

## 10. Deception

The reduction of the detectability of friendly forces against the threat sensors is key to survivability. Techniques are needed that reduce US platform signatures or otherwise deceive threat targeting and intelligence, surveillance and reconnaissance (ISR) sensors.

- Protect high value assets (advanced signature management & deception concepts)
- Materials for signature management (hyper-spectral paints, pigments and patterns)

## Intelligence and Information Warfare Directorate (I2WD)

**Mission:** The mission of I2WD is to ensure information dominance by providing enemy situation awareness, targeting, and electronic combat technology to the warfighter.



I2WD provides effective Intelligence, Surveillance and Reconnaissance (ISR) Sensors, ISR Processing, Electronic Warfare, Air/Ground Survivability (Force Protection), Information Operations, and ISR Modeling & Simulation (M&S) materiel capabilities to the U.S. Army through:

- Superior technology research, development, prototype demonstrations, and rapid transitions of state of the art technologies into systems
- Development, production and fielding of specified equipment in support of Army and National Intelligence requirements and Law Enforcement Agencies (LEA)
- Engineering and management support to Program Executive Officers (PEOs) and their Program Managers (PMs) in the development, production and fielding of systems

### Business Areas Include:

- Intelligence, Surveillance and Reconnaissance (ISR) Sensors
  - SIGINT
  - MASINT
  - RADINT
  - Multi-INT

- ISR Processing
- Electronic Warfare (EW)/Force Protection
- Information Operations (IO)
- Combat Identification (CID)
- Modeling and Simulation (M&S)

## Intelligence and Information Warfare Directorate Technology Needs

### 1. Intelligence, Surveillance and Reconnaissance ISR Sensors

Systems engineering for development and integration of Army Signals Intelligence (SIGINT), Measurements and Signatures Intelligence (MASINT), and Radar sensor systems, airborne, ground-based vehicle or portable, to detect, locate, classify, and identify targets.

### SIGINT

SIGINT is obtained by quantitative and qualitative detection, location, classification, identification, exploitation and subsequent analysis of Radio Frequency (RF) signals derived from specific sensors. SIGINT consists of two categories: Communications intelligence (COMINT) is directed at the analysis of the source and content of voice

message traffic. While most military communications are protected by encryption techniques, computer processing can be used to decrypt some traffic. Electronic intelligence (ELINT) is devoted to analysis of non-communications electronic transmissions.

### General

- Antenna design for airborne and ground platforms
- RF techniques to enhance ESM/SIGINT receivers
- Adaptive/Smart Antenna Technology to Improved Standoff Distances
- Co-channel & interference mitigation
- Adaptive Power
- Advanced Waveforms
- WB Tuners
- De-interleaving
- Multi-Mode DF

- Exotic Communications
- Predictive Algorithms

## COMINT

- Conventional analog/digital signals & LPI
  - COMINT enhancements for conventional signals
  - Advanced receiving techniques
  - Precision Geolocation
  - Specific Emitter Identification
  - Issues peculiar to High Frequency Electronic Support Measures
- Modern Signals
  - Communications Intelligence enhancements for modern signals
  - Advanced receivers and receiving techniques
  - Precision Geolocation
  - Specific Emitter Identification
  - Data Thinning & Autonomous Target Search

## ELINT

- COMINT enhancements for ELINT
- Advanced receivers and receiving techniques
- Precision Geolocation
- Specific Emitter Identification
- Data Thinning & Autonomous Target Search

## MASINT

Measurement and Signature Intelligence (MASINT) is scientific and technical intelligence information obtained by quantitative and qualitative analysis of data (metric, angle, spatial, wavelength, time dependence, modulation, plasma, and hydromagnetic) derived from specific technical sensors of many types (acoustic, seismic, RF, unintentional radiation, EMP, laser, etc) for the purpose of identifying any distinctive features associated with the source, emitter, or sender and to facilitate subsequent identification and/or measurement of the same.

- Active and Passive MASINT Technology
- System of Systems Integration of Delivery, Processing and
- Dissemination Systems

## RADINT

Radar as a sensor provides estimates of certain characteristics of its surroundings of interest to a user, most commonly the presence, position, and motion of such objects as aircraft, ships, or other vehicles in its vicinity, known as Radar Intelligence (RADINT). The term Radar applies to both the technique and the equipment used in combinations or with other elements of more complete systems to provide the user with a full range of sensor capability in determining direction, distance, arrival angle and speed of enemy vehicles, weaponry or systems that threaten to our forces.

- Radar Techniques for enhanced precision target detection and location to include very low radar cross section targets such as mortars
- SAR/GMTI

- Foliage Penetration
- Structure Penetration (STTW)
- RF Tags/Covert TTL
- Radar Applications

## Multi-INT

Combination of discrete sensors or sensor data from multiple disciplines (ie, SIGINT, MASINT, RADINT, etc) into physically or logically-integrated payloads with the explicit purpose of increasing probability of target detection, classification, identification, and tracking; decreasing false alarms; and improving accuracy and the quality of exploited intelligence.

- Mixing Sensor Packages
- Control and Cross-Cueing
- Ground Platforms for Multi-INT
- Multi-INT Sensors for Urban Operations

## 2. Intelligence, Surveillance And Reconnaissance ISR Processing

Software architectures, databases, algorithms, protocols, tools, and techniques for dissemination, exploitation, and analysis of data derived from ISR sensors

- Data Fusion
- Multi-Intelligence Analyst Functions
- On-Board, Multi-Sensor Management and Data Fusion
- Autonomous Closed-loop Cueing Architecture
- Sensor-Level Fusion Software to enable all-source reasoning and enhanced threat awareness
- Novel approximate game-theoretic and deception-sensitive algorithms
- Adversarial reasoning/high quality in-execution predictive analysis tools
- Cognitive information processing algorithms
- Message/data analysis and interpretation
- Estimating Enemy Intent tools
- SA/SU tools
- ISR Planning/Re-planning tools
- IED Attack Forecasting
- User-directed knowledge discovery tools to find patterns
- Intelligent Information Retrieval
- Foreign Language Auto-Translation

## 3. Electronic Warfare/Force Protection

Electronic Warfare includes any military action involving the use of electromagnetic energy to control the electromagnetic spectrum. Electronic Attack is the use of electromagnetic energy to attack

personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability. Electronic Protection is the use of electromagnetic energy to protect personnel, facilities, or equipment from any effects of friendly or enemy employment of EW that degrade, neutralize, or destroy friendly combat capability, or as detection and countermeasures capabilities against missiles, rockets, mortars, improvised explosive devices, and other ordnance.



- Radio Frequency Sensors/ Receivers/ Countermeasures
- Laser Jamming Sources for Infrared Countermeasures
- Low Cost Multi-Spectral Electro-Optics/Infrared/Ultraviolet Sensors for Warning/Countermeasure and Hostile Fire Location
- Self Protection Technology vs MANPADS
- Precision Angle of Arrival, Wide Bandwidth RADAR Warning Sensors
- Wide Instantaneous Bandwidth Coherent RADAR Countermeasures and Deception Modulators
- Electronic Deception & Advanced Signature Management vs Passive Target Acquisition and Tracking Radars.
- Projectile Warning / Tracking using LADAR
- Directed Missile Countermeasure Device Integrated with Missile or Laser Warning for Tank Protection
- Communications Electronic Attack
- Wideband Digital Transceivers and High Power Amplifiers
- Wearable Jammers & Antennas

- Advanced Countermeasures Techniques (Software)
- EO/IR & RF Countermeasure Devices (Hardware)
- Alternate Architectures
- Integrated CREW/Communications (Improved I/O)
- EMI/EMC Reduction
- Increased Antenna Gain & RF Spectrum Coverage
- Reduced Antenna SWAP\$ & Visual Signature
- Increased Efficiency (reduced system power/increased transmit power)
- Increased IBW
- Decreased Internal Heat Generation and SWAP
- Decreased Scan Time
- IED DF
- SIGINT Integration
- Increased Processing Power
- RF Probing Techniques
- Neutralization Techniques
- Common Transmitters for ECM & SIGINT
- Clutter Reduction and False Alarm Algorithms
- Alternative Multi-Band Laser Concepts
- Non-Mechanical, Selectable Beam-Steering
- Mid-Wave Optical Fiber
- Threat Warning Sensor for Ground Combat Vehicles
- Inexpensive Focal Plane Arrays (FPAs)
- Two-color IR Sensor/Processing Architecture
- OTM Algorithms to ID/Hand-Off Threat to Active Protection System
- Threat Signature Database

## 4. Information Operations

IO integrates all aspects of information to support and enhance the elements of combat power, with the goal of dominating the battlespace at the right time, at the right place, and with the right weapons or resources. IO are defined as continuous military operations within the military information environment (MIE) that enable, enhance, and protect the friendly force's ability to collect, process, and act on information derived from datacomm and telecomm networks to achieve an advantage across the full range of military operations; IO include interacting with the global information environment (GIE) and exploiting or denying an adversary's information and decision capabilities.

- Real Time, Stealthy, Logical Network Access, Discovery, Exploitation and Countermeasures-Non-Cooperative

- Real Time, Stealthy, RF Access, Communications and Non-Communications Network Discovery, exploitation and Countermeasures-Non-cooperative
- Real Time, Stealthy, Active Protection and Defense of U.S. Army Tactical Information Networks; Exploitation and Countermeasures – cooperative
- Predictive Traffic Analysis (TA) Algorithms including friend/foe analysis
- Language Auto-ID/Auto-Translation
- Digital Forensics
- Command and Control Protect, Network Vulnerability, C4-ISR Penetration Testing and Vulnerability Analyses

## 5. Combat Identification

Combat Identification (Combat ID) is the process of attaining an accurate characterization of detected objects in the joint battlespace to the extent that high confidence and timely application of military options and weapons resources can occur. Depending on the situation, this characterization may be limited to "friend", "enemy", or "neutral". In other situations, other characterizations may be required, including but not limited to class, type, nationality, and mission configuration.

- Cooperative Target Identification
- Non-Cooperative Target Identification
- RF Tags

## 6. Modeling and Simulation

Modeling and simulation (M&S) provides virtual duplication of products and processes, and represents those products or processes in readily available and operationally valid computational environments. Use of such models and simulations can be applied throughout a system's life cycle in support of all aspects of systems engineering and can reduce the cost and risk of "life cycle" activities.

- Modeling and simulation for tactics, techniques, and procedures (TTPs)
- Threat Characterization (EO/IR & RF)
- Modeling and simulation of targets and target environment
- Net-centric survivability in a simulation environment
- HIL OneSAF wargaming scenarios
- Physics-based ISR sensor models

## Command and Control (C2) Directorate

**Mission:** Research, develop, systems engineer, design, fabricate, integrate

and demonstrate technologies and capabilities, and provide unequalled support to PMs in all core mission areas— Battle Command, Portable and Mobile Power, Military Platform Integration and Prototyping, Environmental Control Systems, and Navigation—with the aim of transitioning optimum capabilities to The Warfighter as quickly as possible.

### C2D Business Areas include:

**Command and Control** – develop enabling technologies to support and advance the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of a mission.

**Army Power** – research and develop power and energy storage and generation technologies for all operational platforms requiring power from soldier C4ISR, to mobile, and aircraft systems.

**Position/Navigation** – provide an affordable, reliable and accurate source of position, orientation and movement information to enable enhanced situational awareness and training for soldiers and other platforms, especially in urban and other GPS denied environments.

**Integrated Ground and Air Command and Control Platform Systems** – develop tactical command and control platform systems by designing, fabricating, and integrating the Command, Control, Communications, Intelligence, Surveillance, and Reconnaissance systems into vehicular, sheltered, watercraft, and dismounted platforms.



## Command and Control Directorate Technology Area Needs:

### 1. Battle Command –

The concepts of C2 and Battle Command are closely linked. Commanders execute command and control by combining the art of command and the science of control to accomplish missions – Battle Command. Below are some of the technologies (i.e. science) that are required to make the art possible.



### Visualization Of Battlefield Information

- Integrated views of different perspectives of Common Relevant Operational Picture (CROP) Situation Awareness (SA) as required to support dynamic, ad-hoc team coordination and management of on-going operations
- Automated interpretation of evolving CROP SA information and alerting of significant deviations from assumed execution models used for planning of operation
- Visualization concepts for SA in urban and asymmetric warfare environments

### Service Based Software Technologies For Plan Execution And Monitoring

- Technologies for the development and analysis of Course of Action (COA) in asymmetric warfare that incorporates Diplomatic, Information, Military and Economic (DIME) / Political, Military, Economic, Social, Infrastructure, and Information (PMESII).
- Automated or highly computer assisted generation of threat target engagement and maneuver unit Courses of Action (COA) in highly mobile operations
- Automated plan execution and monitoring in contingency operations and nation building operations
- Automated workflow engine that is user programmable (Standard Operating Procedures or plan driven) and provides management of data exchanges and tasking of resources (computer and human) available in the C2 system to support operational threads, along with execution

### Mobile Computing Middleware

- Infrastructure software to support the real-time connection of dynamic, ad-hoc operations management teams and facilitate the efficient information distribution of needed information between team members in a network centric, global information grid environment
- Automated CROP SA information and transaction synchronization services to assure that mobile users have timely and accurate information
- Analysis, forecasting, and modeling and simulation of the impacts of the Future Force CONOPS on tactical network loading
- Low overhead service discovery synchronization strategies for use in tactical networks (i.e. ubiquitous service awareness while online/off-line)
- Service discovery semantic query language
- Dynamic intelligent bandwidth management as a function of Radio/Transmitter Quality of Service
- Distributed service load balancing to avoid resource/system starvation

### Rapid Capture Of Commanders' Knowledge

- Software Agents that perform various C2 staff information processing, analysis and presentation functions in a tactical/doctrine correct manner as required to support the Commander's C2 decision-making processes
- Knowledge capturing software agents that capture a Commander's decision-making and risk taking preferences in dealing with the information provided by the C2 staff information processing, analysis and presentation agents and automatically tailor/optimize the performances of those agents to comply with the commanders preferences

### Contextual Information Management

- Prioritization, transport, and discovery of semantic knowledge in ad-hoc, tactical networks
- Army/DOD metadata/ontology mapping across Service-Oriented Architecture (SOA) boundaries
- Process information for context
- Identify and compute relationships of information to mission, plan, threat and other entities
- Dynamically relate informational context to enable fast and cognitive response to: Commanders Critical Information Requirements (and similar information needs), Mission Execution, Course of Action Generation, Course of Action Analysis Collaboration and Planning.
- Establish dynamic links between sources of information and Warfighters who may need this Information

### Knowledge Management

- Tracking and auto linking of information sources and requirements associated with the performance of critical operational commander tasks

- Auto tracking of commander's preferences for linking to information, presentation of data, and task/process execution sequences/priorities in the context of mission execution

### Web-Based Technologies For Planning

- Representation of CROP/SA and XML-based Operations Order (OPORD) and Operations Plan (OPLAN) information constructs for improved joint and coalition force data exchange interoperability
- Digitized, XML based OPORD/OPLAN authoring tools
- Web-Service based tools/applications to support detailed COA Planning and Analysis accessible from within Web-based Portal C2 Windows

### Common Graphics Unit Interface (GUI) Interface To Virtual Services

- Common Command and Control (C2) Battle Management Language (BML) and syntax that can be used to communicate commanders' intent consistently to both manned and unmanned autonomous combat systems and C2 simulation support systems
- Automated C2 BML command interpretation services that will translate received commanders tasking to autonomous/robotics combat systems in appropriate actions

### Visual Displays

- Flexible Displays: Small Molecule Organic Light Emitting Devices (OLEDs), Light Emitting Polymer (LEP) OLEDs, LCD, Electrophoretic Ink)
- Glass OLEDs
- Large Screen, Mega-Pixel Resolution Displays:
- Mobile Flat-Panel Large Screen Display (LCD), Plasma Display Panels
- Projection Display Devices (Digital Micro-mirror Devices)
- Hand-Held (PDA displays)
- Display Optics and Nanotechnologies
- Human Computer Interface, Touch Screen I/O Devices
- Software Visualization Tools
- C4ISR Display Integration
- Micro-displays (Helmet mounted displays)
- Information Processing (Graphical for situation awareness)

### Immersive 3D

- 3D Flat-Panel Display, Projection, and Micro-displays
- Auto-stereoscopic (glasses free) Display
- Polarized, Angled-Pixel (passive) 3D Eyewear and Displays
- Liquid Crystal Shutter (active) 3D Eyewear and Displays

- 3D Advanced Graphics
- 3D Visualization Software
- Virtual Reality Input/Output (IO) Devices (six degree-of-freedom)
- RF Motion Tracking Sensors
- IR Stereo Synchronization Emitters
- Synchronized Clustered High-End Graphics Workstations
- Full Body Motion Uniform
- Motion Platform – containing frequency vibration data to permit 6 Degrees of freedom interaction

## Interactive Speech

- Common Software Interface
- User Friendly Developers Toolkit
- Non-Stationary Noise Robust
- Impulsive Noise Tolerant
- True Speaker Independence
- Natural Language
- Tactical/Conversational Speech Recognition
- Intent Understanding
- Template Code Morphing
- Automated Sub Dialect/Linguistics Reference Dictionary building and content recognition

## Machine Language Translation (MT)/Natural Language Processing (NLP)

- Multi-Lingual Text and Audio Corpora Development and Annotation
- System Integration/Engineering of Machine Translation MT/NLP Systems
- Evaluation of MT System Accuracy, Coverage & Stability
- Identification, Augmentation and Integration of Military Domain Lexicons
- Research and Development of Tools to Automatically & Semi-Automatically:
  - Annotate Text
  - Evaluate Translation Accuracy
  - Transliterate Corpora
- NLP Generation of Robust Sync Matrices and other Planning Documents
- NLP Extraction of Who, What, Where, When, Why, Which, and How
- Special Word Processing Tools for Right To Left Languages Such as Arabic & Hebrew
- High Quality Arabic, Hebrew and Farsi Parsers and Generators

## 2. Position/Navigation

Technologies to enhance the Global Positioning System user equipment and to provide more robust, anti-jam position and navigation capabilities.

Investigate positioning, navigation, and tracking sensor/integration technologies to provide position, velocity and time information to support operational and training requirements, especially in hostile electromagnetic interference and other radio frequency degraded environments.

## Positioning, Navigation and Timing (PNT) Technology Needs

- Global Positioning System (GPS) Anti-Jam Devices, Techniques and Capabilities
- Micro Electro-Mechanical System (MEMS) Inertial Measurement Unit (IMU) and integration techniques to improve performance in GPS masked/denied environments for tactical vehicles and dismounted applications
- Size/Weight/Power and Cost Reduction Navigation System Technologies for Tactical Vehicles and Dismounted Applications
- GPS and Navigation System Modeling and Simulation
- Correlation of Digital Imagery, Live Video and other Available Sensors for Positioning, Guidance and Targeting for Aerial and Ground Applications
- Visionics Technology Application to Navigation
- Storage, Compression and Utilization of Dense Map/Imagery Databases
- Positioning/Navigation Sensor Technologies for Manned/Unmanned Operation In Complex Urban Environments, Buildings, Tunnels and Caves
- Ultra Wideband (UWB) and Low Frequency RF Systems for - Ranging/Positioning In Complex Environments
- Miniature Atomic Clocks
- Low-Power Clocks
- High-Shock Clocks
- Acceleration-Insensitive Oscillators And Clocks
- Miniature Resonators/Filters

## Algorithms for planning, placement, command and monitoring of organic unmanned sensor systems/platforms

- Define a minimum set of Unattended Ground

Sensors (UGS), by type and function, required to form a cluster of UGS to detect threat activities in a particular area

- Algorithms to automatically lay out UGS patterns to cover a given area based on the mission need and available resources
- Monitoring and commanding the sensor clusters to ensure continuous coverage and highest level of detection
- Automated assessment of value of proposed UGS cluster placement (e.g. NAI too big & requires more clusters than allowable, mobility corridor too wide & easy for enemy to avoid UGS cluster(s))

## 3. Future Force Power

Electrochemical systems (batteries, fuel cells, solar panels) require materials that will facilitate efficient ionic movement of electrons between electrodes through a conductive medium and separator. Advances in surface and material chemistry, resilient and conductive separators, new and novel electrolytes will be needed to develop higher energy, higher instant power capable and stable portable power sources for the stringent military environment. In addition, fuel cells require advances in hydride chemistry, activation materials, novel mechanical schemes to develop hydrogen storage and generation, and to develop reformer technologies that can generate hydrogen from battlefield fuels (diesel) or biomasses. Electromechanical systems (generators, wind, heating and cooling) require advances in materials (magnetic, structural alternatives to metal such as composites and ceramics), integrated electronics (hardware and software) and novel engine designs to reduce the power generator set size, weight, noise, IR signature, fuel consumption or mechanical effort by operator.

## Fuel Cells And Hybrid Systems

- Proton Exchange Membrane (PEM) Fuel Cells
- Solid Oxide Fuel Cells (SOFC)
- Direct Methanol Fuel Cells (DMFC)
- Hydrogen Storage, Generation and Separation
- Diesel fuel de-sulfurization and reformer techniques



- Micro-Channel Reactors/Heat Exchangers

## Power Management

- Low Power Electronics and Low Voltage/Low Energy components
- Hardware/Software Design Tools

## Electromechanical Devices And Systems

- Power Electronic, Diagnostic and Prognostic Controls
- Power Distribution and Management
- Under the Hood Power
- Stirling Engines
- Catalytic Fuel Igniter Technology and Small JP-8 Combustors
- Composites and Ceramics (includes mega-materials/nano-composites)
- Signature Suppression Technologies (Noise, Visible, IR & Vibration)
- Environmental Compatibility (-40°C to +71°C)

## Ultracapacitors

- High Power Density Electrochemical Capacitors

## Rechargeable Batteries

- Non-Flammable and High Conductivity Electrolytes (10-3 S/cm<sup>2</sup>)
- Wide Temperature Range (-40°C to +71°C)
- High Energy Density (>350 Whr/kg) and Rate Capability (>75 W/kg)
- High Rate Capability Less Weight/Smaller Size (Volume) with no loss in performance
- Hermetic, Non-Metallic Cell Packaging
- Conformal Cells (Flexible, Wearable) and Modular Cells/Batteries
- Long Shelf Life - 10 Years; Capacity Loss in Storage - 2% per year or less
- Low Cost and/or Dual Use Technology
- Increased Volumetric Efficiency (Prismatic Cells/Batteries)
- Increased Charge Acceptance & Retention
- Cell Balancing Charge Circuitry
- Accurate, Compensated State-Of-Charge Indication (±5% or less)
- Cycling Efficiency and Fast Recharge – less than 1 hour

## Primary (Disposable) Batteries

- Non-Flammable Electrolytes and High Conductivity (10-3 S/cm<sup>2</sup>)
- Wide Temperature Range (-40°C to +71°C)
- High Energy Density (>350 Whr/kg) and High Rate Capability (>75 W/kg)

- Less Weight/Smaller Size (Volume) with no loss in performance

- Hermetic, Non-Metallic Cell Packaging; Novel Cell Packaging Technologies; Abuse Tolerant Cell Designs

- Conformal Cells (Flexible, Wearable) and Modular Cells/Batteries

- Long Shelf Life - 10 Years

- Low Cost and/or Dual Use Technology

- Water Balanced Non-Lithium Cells/Batteries

- Metal-Air Electro-chemistries

## Battery Chargers

- Smart Bus Communication/Compliant/ Chemistry Independent

- Rapid (full charge in less than 30 minutes)

- Small Light Weight Man-Portable and/or Modular Vehicle Mountable

## Heat Actuated Cooling

- Microchannel absorbers/desorbers

- Energy recovery devices

- Corrosion-resistant heat exchangers

## Renewable Energy Sources

- Solar (Flexible)

- Wind (Man-Portable)

- Hydroelectric (Man-Portable)

## 4. Prototype Development & Platform Integration Technologies

Integrated ground and air C2 platform systems are needed for command and control operations in a tactical environment. There are diversified technologies that can be advanced to improve the performance of integrated C2 platforms. Technologies that will enhance the system engineering process to design, develop, manufacture, integrate, and test the integrated C2 platform systems are as follows:

### Remotely Controlled Electro-Mechanical System

- Hydraulically actuated pistons and cylinders systems for reducing set up and teardown times

### Advancement in Material Science

- Lightweight Composite and "Smart" Materials for use in Army's shelter/vehicle applications

### Prototyping Technology Tools

- Virtual Prototyping using Virtual Reality Tools

- Rapid Prototyping Technology Aids

### Electromagnetic Environmental Effects Protection

- Conductive and EMI Resistant Bonding Technologies

- EMI, Tempest, and Lightning Suppression Technologies

## Ruggedized Mechanical and Electrical Components

- Mobility Enabling and Enhancing Technologies Facilitating On-The-Move Operations.

- Equipment Mounting and Installation Technologies/Techniques

- Shelter and Vehicular Internal/External Noise Reduction Technologies

- COTS Electrical Equipment Ruggedized for Tactical Environments

- Advanced Equipment Connector Technologies.

## Heating, Ventilation, Cooling, and Air Conditioning and Power Management

- Innovative Thermal Management and Energy Reuse System

- Advanced Power Management and Distribution System.

- Transit Case Based Thermal Management.

## Expedited Verification and Validation of Integrated C2 Platform Systems

- Accelerated Environmental Testing Technologies

- Highly Accelerated Life Testing (HALT)

- Highly Accelerated Stress Screening (HASS)

## Space and Terrestrial Communications Directorate

**Mission:** Conduct research and development to provide the Warfighter with advanced communication and mobile networking technologies. Our mission is to acquire, develop and integrate secure, seamless tactical communications for the digitized battlefield. S&TCD performs research, development and engineering functions in all aspects of terrestrial, avionics, and space-dependent communications technology to include adaptive, reliable seamless battlefield communications with full electronic counter-countermeasures capability and Information Security (INFOSEC).

S&TCD has the primary responsibility for DOD Communications, Networking and Network Security. Business areas include:

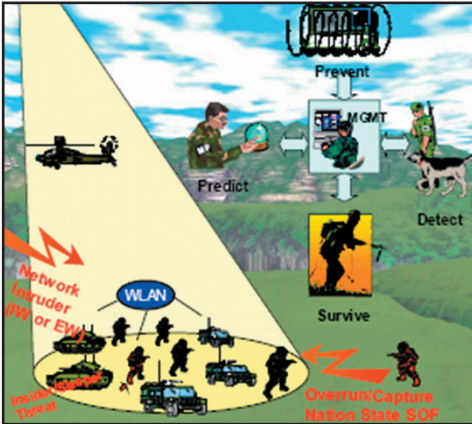
- Information Assurance
- Antennas
- Mobile Networking
- Systems Engineering

## Space and Terrestrial Communications Directorate Technology Needs

### 1. Information Assurance

The enemy has developed sophisticated techniques to not only attack us physically but to at-

tack our information as well. We need to protect the integrity of our information and prevent the attack while operating in the numerous security domains necessary to function effectively in today's joint and coalition environment. The Information Assurance thrust area provides the capabilities to prevent/detect/predict information warfare attacks in tactical networks and respond in a timely manner. Information Assurance mechanisms will be based on commercial and military technologies, as well as research and development where those technologies are lacking.



- Quantum Cryptography
- Mobile Code Security
- Intrusion Detection
- Security Management
- Low Power Information Security
- Automated Malicious Code tools
- Biometrics
- Tactical Cross Domain Solution (CDS)
- Multi Level Security

## 2. Antennas

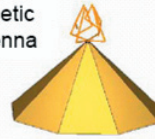
Antennas deployed to the battlefield today provide adequate performance but suffer from a number of deficiencies which limit their usefulness to support the Current and Future Forces. New antenna capabilities are required to address challenges such as: mobility is limited for wide bandwidth, high data rate SATCOM communications, current OTM SATCOM Q,X,Ku/Ka band antenna systems are unaffordable in quantities required for the future force and have large visual signatures, the Omni-directional antennas cannot support the newer JTRS wideband waveforms and link connectivity requirements and are susceptible to jamming, large narrowband antennas can restrict soldier mobility.

- Multiband operation for JTRS
- Airborne, ground vehicle and dismounted antenna products
- Directional antennas
- Affordable, multiband low profile OTM antenna

technology

- Ballistic protection for various vehicular mounted low profile and/or conformal antennas
- Body Wearable Antennas – vest and helmet antennas to support FFW
- Manufacturing technologies used to improve producibility of MEMS devices and ferroelectric materials
- Modeling and Simulation of specific absorption rates/permissible exposure limits for body wearable antennas
- EMI/EMC

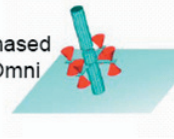
Genetic Antenna



Stacked Bicones



Phased Omni



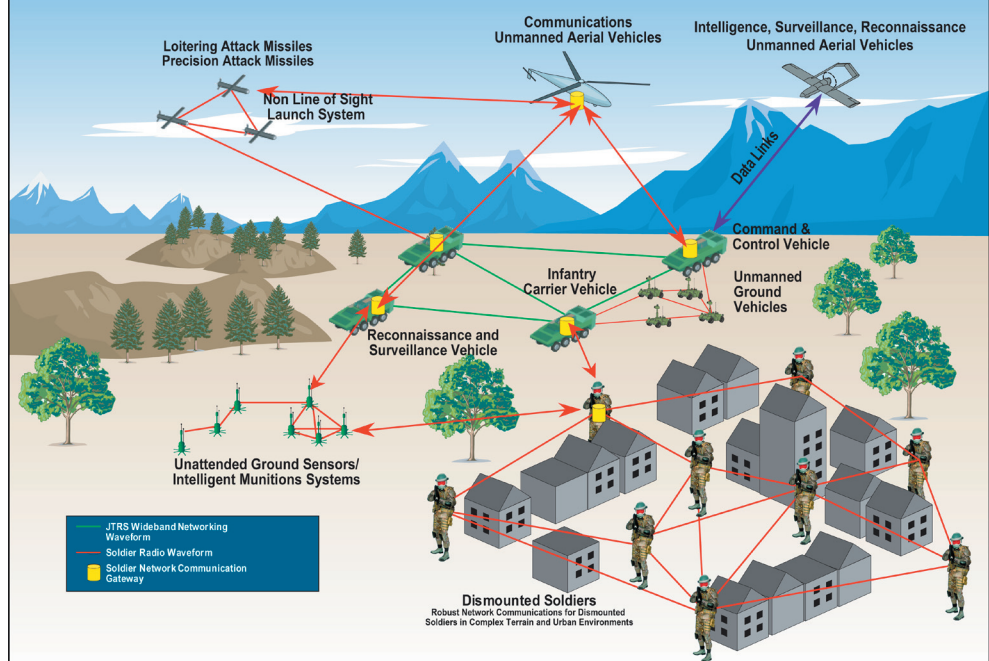
## 3. Mobile Networking

Mobile Networking technologies provide the information pipes over which information flows occur along with the corresponding protocols, waveforms, algorithms, and management processes that allow for steady, uninterrupted, wireless on-the-move (OTM) communications in depth to support dynamic, mobile, ad-hoc operations.

- Reachback/range extension (SATCOM & UAV)
  - OTM satellite communications
  - Handheld tactical satellite terminals
  - Non Line-Of-Sight UAV
- JTRS Communications

- Mobile Laser Communications
- Optical Networking Technologies
- Microelectronics and Nanotechnology
- Unattended Sensors Networking
- Secure Personal Communications
- Squad and Intervehicle Wireless Intercom
- Terrestrial PCS
- Cordless Chip-Based Soldier Communications Systems
- Land Warrior (LW) Leader Radio
- Sub-Terrainian Comms Technologies
- Network Operation
- Configuration/Network Management Software
- Allowing diverse networks composed of terrestrial and space
- Network Mobility (NEMO)
- Must support multi-access and point to point transmission
- Protocol Technologies
  - Ad hoc networking protocols
  - Reliable multicast protocols for mixed and integrated switching networks
  - Dynamic addressing and reconstitution protocols
  - Efficient wireless transmission protocol
  - Geographical routing protocols
- Mobile Agent technology
- Guaranteed Quality of Service algorithms
- Wireless mobile networking

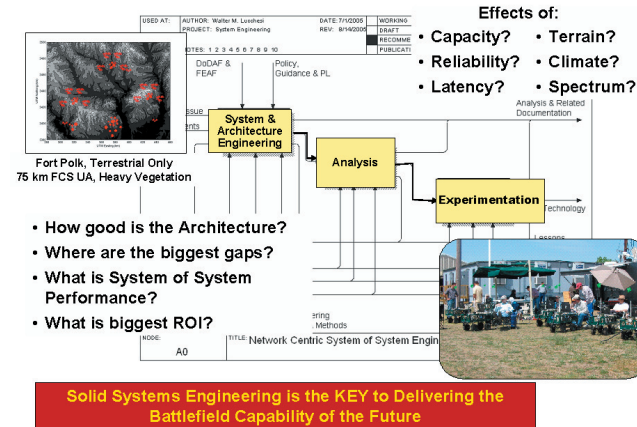
## MOBILE NETWORKING



- Space Time Adaptive processing
- Adaptive waveforms
- Software programmable, multi-mode MODEM
- Radio Frequency Waveforms
- Spectrum utilization for enhanced radio networks
- Spectrum usage optimization scheme
  - Adaptive algorithms and modulation control schemes
  - Turbo coding
  - Trellis coding
  - Ultra wideband
  - Cognitive radio technologies
  - Control based cross layer technologies
  - Cooperative diversity technologies
  - Spatial diversity – space time coding technologies
  - Collaborative radio RX technologies

The blended approach of systems engineering, architecture, and M&S research and development, infrastructure, technical interchanges with industry and academia, engineering analysis, and experimentation are used effectively to shorten the development cycle while determining how best to meet user communications requirements for current and future force.

- System of System (SoS) analysis design and performance



## 4. Systems Engineering

A multifaceted approach is employed to accomplish the mission of performing relevant Systems Engineering analysis with state of the art system engineering principles, practices and concepts.

CERDEC is interested in establishing quality partnerships through Cooperative Research and Development Agreements (CRADAs) to further develop the technologies listed in this document. CERDEC looks forward to collaborating with industry, academia, and other Government agencies (both federal and non-federal) through the establishment of CRADAs.



For additional information contact:  
**CERDEC Headquarters**  
 Office of the Associate Director for Technology & Strategic Planning  
 Fort Monmouth, New Jersey 07703-5201  
 732-427-2690

